

1	Introduction — 1
1.1	What is an analog computer? — 1
1.2	Direct vs. indirect analogies — 2
1.3	A short history of analog computing — 3
1.4	Characteristics of analog computers — 8
2	Computing elements — 11
2.1	Machine units — 11
2.2	Summer — 12
2.3	Integrators — 17
2.4	Free elements — 24
2.5	Potentiometers — 25
2.6	Function generators — 30
2.7	Multiplication — 33
2.8	Comparators and switches — 35
2.9	Input/output devices — 36
3	Analog computer operation — 39
4	Basic programming — 47
4.1	Radioactive decay — 49
4.1.1	Analytical solution — 50
4.1.2	Using an analog computer — 51
4.1.3	Scaling — 54
4.2	Harmonic functions — 56

4.3	Sweep — 61
4.4	Mathematical pendulum — 62
4.4.1	Straightforward implementation — 63
4.4.2	Variants — 64
4.5	Mass-spring-damper system — 65
4.5.1	Analytical solution — 66
4.5.2	Using an analog computer — 69
4.5.3	RLC-circuit — 70
5	Special functions — 73
5.1	STIELTJES integral — 73
5.2	Inverse functions — 74
5.2.1	Square root — 75
5.2.2	Division — 76
5.3	$f(t) = 1/t$ — 77
5.4	Powers and polynomials — 77
5.5	Low pass filter — 78
5.6	Triangle/square wave generator — 80
5.7	Ideal diode — 80
5.8	Absolute value — 82
5.9	Limiters — 83
5.10	Dead zone — 84
5.11	Hysteresis — 85
5.12	Maximum and minimum — 85
5.13	Bang-bang — 86
5.14	Minimum/maximum holding circuits — 87
5.15	Sample & Hold — 88
5.16	Time derivative — 89
5.17	Time delay — 91
5.17.1	Historic approaches to delay — 92
5.17.2	Digitization — 93
5.17.3	Sample and hold circuits — 94
5.17.4	Analog delay networks — 96
5.18	Transfer functions — 103
5.19	Exponentially mapped past — 103
6	Examples — 109
6.1	Displaying polynomials — 109
6.2	Chemical kinetics — 110
6.3	SEIR model — 114
6.4	Damped pendulum with external force — 117
6.5	MATHIEU's equation — 119

6.6	VAN DER POL's equation — 122
6.7	Generating BESSEL functions — 125
6.8	Solving the one-dimensional SCHRÖDINGER equation — 127
6.9	Ballistic trajectory — 130
6.10	Charged particle in a magnetic field — 131
6.11	RUTHERFORD-scattering — 135
6.12	Celestial mechanics — 138
6.13	Bouncing ball — 141
6.14	Zombie apocalypse — 144
6.15	RÖSSLER attractor — 146
6.16	LORENZ attractor — 148
6.17	Another LORENZ attractor — 149
6.18	CHUA attractor — 151
6.19	Nonlinear chaos — 155
6.20	AIZAWA attractor — 156
6.21	NOSÉ-HOOVER oscillator — 157
6.22	The SQ_M model — 160
6.23	The DUFFING oscillator — 161
6.24	Rotating spiral — 163
6.25	Generating an EULER spiral — 165
6.26	HINDMARSH-ROSE model — 168
6.27	Simulating the flight of a glider — 171
6.28	Flow around an airfoil — 176
6.29	Heat transfer — 180
6.30	Two-dimensional heat transfer — 186
6.31	Systems of linear equations — 187
6.32	Human-in-the-loop — 193
6.33	Inverted pendulum — 198
6.34	Elastic pendulum — 204
6.35	Double pendulum — 206
6.36	Making Music — 210
6.37	Neutron kinetics — 214
6.38	Smooth sorting — 216
7	Hybrid computing — 219
7.1	Hybrid controllers — 220
7.2	Basic operation — 222
7.3	Shell trajectory — 224
7.4	Data gathering — 227
7.5	Training an AI with an analog computer — 230
7.6	Hybrid solution of systems of linear equations — 236
7.7	Solving PDEs with random walks — 238

8	Summary and outlook — 243
A	The Laplace transform — 247
A.1	Basic functions — 247
A.1.1	Step function — 248
A.1.2	Delta function — 249
A.1.3	Ramp function — 249
A.1.4	Exponential and trigonometric functions — 250
A.2	LAPLACE transforms of basic operations — 251
A.3	Further characteristics — 252
A.4	Inverse LAPLACE transform — 252
A.5	Example — 253
A.6	Block diagrams and transfers functions — 254
B	Solving the heat equation with a passive network — 256
C	A simple hybrid controller for THE ANALOG THING — 261
D	An oscilloscope multiplexer — 265
E	A $\log()$ function generator — 269
F	A sine/cosine generator — 271
G	A simple joystick interface — 273
H	The Analog Paradigm bus system — 275
I	HyCon commands — 277